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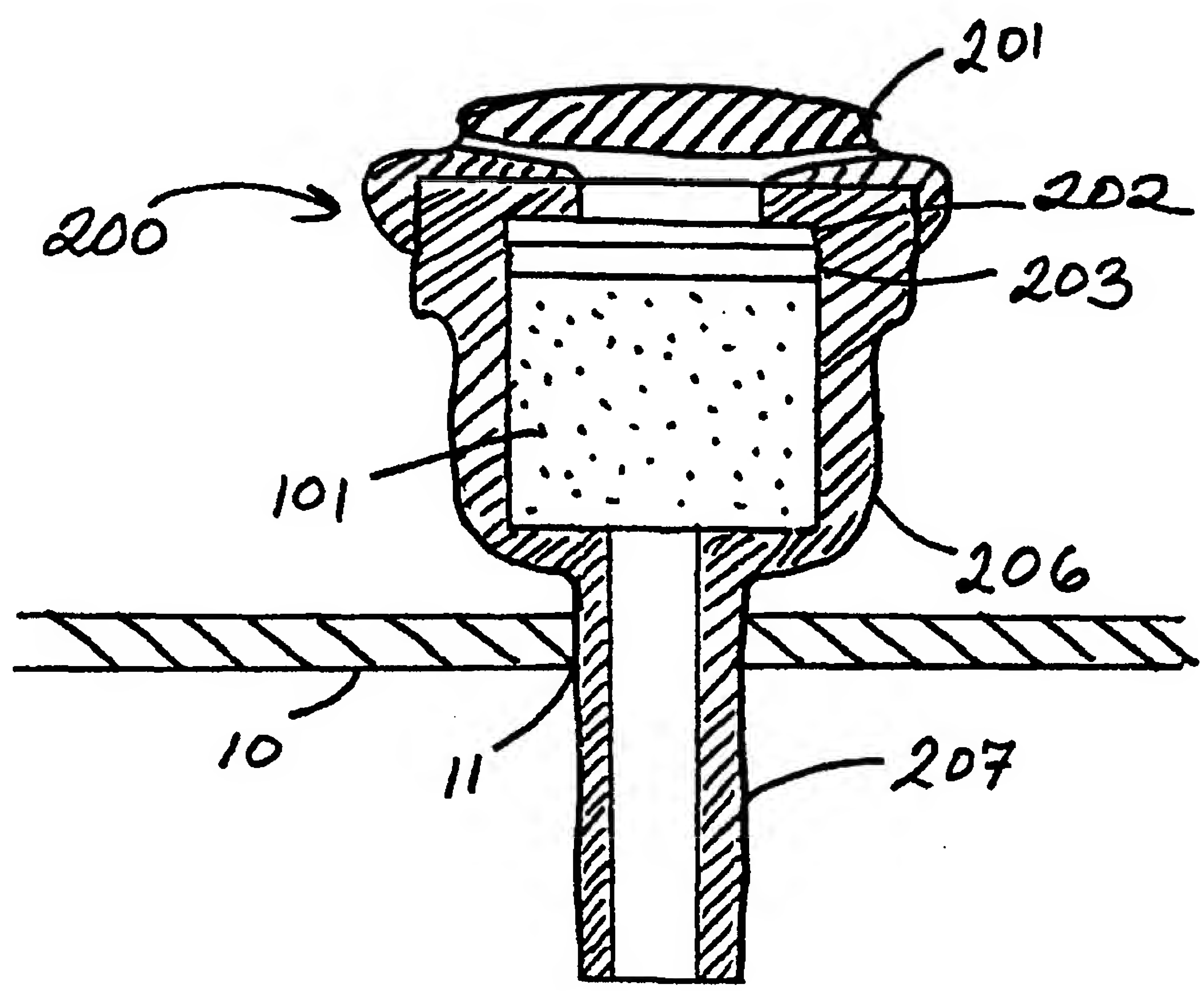
(54) Title: HEADLIGHT ASSEMBLY HUMIDITY CONTROL SYSTEM

(57) Abstract

An apparatus and method for reducing and preferably eliminating the condensation in enclosed lamp or light housings is disclosed. The vent system of the present invention prevents both liquid and vapor forms of water or other liquid from entering the lamp housing. The vent system (200, 200', 210) comprises a water vapor permeable membrane (202), a dessicant (101), and a diffusion channel (203) positioned exterior to the lamp housing (10) and connected to the interior of the lamp housing by an elongated duct through which air from the lamp housing must pass prior to passing through the desiccant, diffusion channel or membrane. The vent system can be positioned on the exterior of the lamp housing, with the duct extending into the interior of the lamp. The duct (207, 207') preferably extends in close proximity to the light bulb (16) in the lamp housing.



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HEADLIGHT ASSEMBLY HUMIDITY CONTROL SYSTEM

FIELD OF THE INVENTION

The present invention generally relates to a vent system for reducing condensation in enclosed lamp housings such as vehicle headlights. More particularly, the vent system comprises a water vapor permeable membrane and a diffusion channel, and optionally a desiccant and an internal duct.

BACKGROUND

Many vehicle head lamps or lights, brake lamps, running lamps, turn signal lamps, fog lamps, etc. typically include a light bulb and a reflector located in an enclosed housing. The housing is sealed with the exception of breather parts to prevent water, dirt, oils, and other contaminants from reaching the bulb, the reflective surfaces, and the light transmitting surfaces of the lamp. Often, the temperature and pressure cycling within the housing, caused by the intermittent use of the lamps, results in moisture collecting and condensing on the interior of the housing which inhibits light output from the lamp.

Various venting concepts and desiccant assemblies have been used to minimize condensation build-up in enclosed lamp housings. For example, some lamps have a desiccant attached to the interior walls of the housing to prevent fog formation on the internal walls of the lamp or its reflector. The desiccant adsorbs any water vapor that enters the housing when the lamp is off. When the lamp is turned on, heat generated by the bulb dries the air and the desiccant, thereby regenerating the desiccant.

Although this type of desiccant assembly system provides adequate moisture adsorption under some conditions and is capable of being regenerated by the heat produced by the light bulb, a number of difficulties have been identified with these types of systems. For example, the desiccant package is not easy to position inside the housing and often requires a special sub-housing to support the desiccant within the housing. Additionally, some desiccants, sub-housings, or both are not able to withstand the high temperatures generated by some light bulbs. Thus, the desiccant must be located at least a minimum distance from a high temperature

bulb or must be shielded from the bulb, for example, placed behind the reflector. Additionally, regeneration of the desiccant achieves little advantage because any moisture release from the desiccant is contained in the headlight housing. Once the temperature is decreased, the desiccant will readsorb the moisture. Also, as air is exchanged between the headlight and atmosphere during on and off cycling, the desiccant may become saturated and lose its ability to collect additional moisture. With many of these systems, the desiccant is not protected from ambient moisture which can diffuse into the headlight during idle periods and adsorbed by the desiccant, thereby limiting the capacity of the desiccant.

Vent systems to reduce condensation by increasing the airflow through the lamp housing have also been used. Generally, the ambient or atmospheric air outside of the lamp housing is below the water vapor saturation point. When atmospheric air is passed through the lamp housing, moisture inside the housing is collected by the atmospheric air moving through the housing and is removed. Vent systems using this method of moisture removal generally have multiple vent openings positioned at optimal point on the housing so as to optimize air flow and thus moisture removal. Although such vent systems provide a method of increasing the air flow through the housing, a negative effect on lamp performance is noted. In particular, these venting system often create an opportunity for foreign materials and liquid water to enter the lamp housing.

Vents have also been used with closed housings to equalize pressure differentials due to changes in environmental conditions (e.g., when the bulb heats up, outside temperature changes, etc.) while minimizing the entry of water and dirt into the housing. Such vents may incorporate microporous materials such as PTFE membranes (e.g., GORE-TEX® membranes, available from W.L. Gore and Associates, Inc., Elkton, MD), modified acrylic copolymer membranes (e.g., VERSAPORE® membranes, available from Gelman Sciences, Ann Arbor, MI), or other microporous materials. Such membranes are commonly used to relieve pressure from lamps and have been effective in preventing entry of liquid water and foreign materials into lamp housings.

Microporous membrane vents, such as described above, are sold in many configurations. For example, microporous materials are available with plastic

housings to protect the material from damage and contamination and to simplify installation. Some microporous material vents are supplied with woven and/or nonwoven fabric covers that provide protection for the microporous material. Microporous materials with or without fabric supports have been made into products that incorporate adhesives for the purpose of attaching the product to a device to provide venting.

Conventional microporous vents designed for vehicle lighting applications have addressed pressure relief, ease of installation, durability, exclusion of liquid water and foreign materials, etc. The conventional design requirements for the microporous vent are based on maintaining an internal pressure near ambient within the housing during thermal cycling of the lamp. The vent surface area is designed based on the permeability of the microporous material and the desired exchange volume of the lamp air. However, they do not stop moisture from entering the lamp and potentially fogging when subjected to a temperature change.

PCT Application having Publication No. WO 98/31966 to Gore Enterprise Holdings, Inc. teaches a system for reducing the condensation in enclosed lamp housings by providing at least one condensation vent having a vent opening in a lamp housing so that the total area of the vent openings is greater than 132 mm^2 (approximately 0.5 in^2). The condensation vent includes a water vapor permeable membrane which resists liquid water and other contaminants from passing therethrough, yet permits water vapor to pass freely. The condensation vent may be incorporated within, on, or in the lamp housing.

SUMMARY OF THE INVENTION

The present invention is directed to a system for preventing the entrance of moisture, both liquid water and water vapor, into a lamp housing. The present invention is also directed to a system for removing any moisture from the interior of a lamp housing, thereby reducing the tendency for the lamp to fog.

In one aspect of the present invention, a humidity control system for preventing condensation in a lamp or headlight is provided, the lamp comprising a lamp housing, a bulb, and possibly a reflector. The lamp housing preferably has a hole therein through which is inserted the humidity control system, the system

comprising a permeable membrane, a diffusion channel, and a desiccant enclosed in a housing or body, and a duct. The duct has a longitudinal length and an interior cross-section area perpendicular to the length, and is duct sized so that the cross-section area of the duct is less than the width of the housing or body which houses the permeable membrane, diffusion channel, and desiccant. The duct is positioned to extend from the housing or body, preferably through a hole in the lamp housing, to the interior of the lamp housing, so as to provide a flow of air between the lamp housing exterior, i.e., the atmosphere ,and the lamp housing interior, the air flowing through the membrane, diffusion channel, desiccant and duct.

In a preferred embodiment, the duct extends into the lamp housing a distance so that the end of the duct is positioned in close proximity to the bulb. Preferably, the duct extends to within about 10 centimeters of the bulb, more preferably within about 7 cm of the bulb. The duct may be incorporated into various lamp features, such as a light shroud, that may be present in the lamp.

In a second aspect of the present invention, the humidity control system comprises a permeable membrane and a diffusion channel, because in some environments it may be desired to eliminate the desiccant and duct features.

These features of novelty and various other advantages which characterize the invention are pointed out with particularity in the claims annexed hereto and forming a part hereof. However, for a better understanding of the invention, its advantages, and the objects obtained by its use, reference should be made to the drawings which form a further part hereof, and to the accompanying descriptive matter, in which there is illustrated and described a preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a cross-sectional view of an enclosed vehicle lamp incorporating a first embodiment of a humidity control system of the present invention;

Figure 2 is an enlarged cross-sectional view of the humidity control system shown in Figure 1;

Figure 3 is an exploded perspective view of the humidity control system shown in Figures 1 and 2;

Figure 4A is an exploded perspective view from the top of a second embodiment of the humidity control system of the present invention;

Figure 4B is an exploded perspective view from the bottom of the humidity control system shown in Figure 4A;

Figure 5 is an enlarged bottom view of a diffusion channel;

Figure 6A is an enlarged perspective view of the diffusion channel shown in Figure 5 and an adjacent impermeable layer;

Figure 6B is an exploded perspective view of the diffusion channel and impermeable layer shown in Figure 6A together with a screen;

Figure 7 is an enlarged bottom view of the diffusion channel and impermeable layer shown in Figure 6A;

Figure 8 is an enlarged cross-sectional view of a second embodiment of a humidity control system of the present invention in a first position;

Figure 9 is an enlarged cross-sectional view of the second embodiment of a humidity control system of the present invention in a second position;

Figure 10 is a cross-sectional view of a third embodiment of a humidity control system of the present invention;

Figure 11 is an enlarged cross-section of the humidity control system shown in Figure 10; and

Figure 12 is a cross-section taken along line 12-12 of Figure 11.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention relates to systems for reducing or eliminating condensation inside enclosed vehicle lamps or headlights, for example, automotive, motorcycle, machinery (for example, construction equipment, farm implements, etc.), and boats. The lamps may be either front lamps (i.e., located on the front of the vehicle, as in the case of headlights, and also turn signals, running lamps, fog lamps, etc.) or rear lamps (i.e., located on the rear of the vehicle, as in the case of brake lights, back-up or reverse lights, turn signals, etc.). In addition, the present

invention is suitable for use with other lighting applications, such as street lights or other outdoor light fixtures where condensation on the interior of the housing or lens could detrimentally affect not only the light output, but also such features as cosmetic appearance, light bulb life, and the like.

The enclosed vehicle lamp housings suitable for the present invention may have one enclosed chamber or multiple enclosed chambers. Alternatively, the enclosed vehicle lamp housing may have multiple chambers that are separated by partial walls or partitions, such that the walls or partitions do not isolate these chambers from one another and air can pass between the chambers.

Depending on the location of the lamps, the environments to which the lamps are exposed can vary considerably. For example, lamps that contain higher wattage bulbs, for example headlights as compared to turn signals, experience higher temperatures during use. Additionally, the duration and frequency of use can cause higher temperatures. Heat from an engine can have an affect on the conditions that a lamp at the front of the vehicle experiences compared to a rear lamp. Thus, with respect to the performance of the humidity control system of the present invention, many factors must be taken into account. Accordingly, a variety of humidity control systems according to the present invention are contemplated.

Referring now to the Figures, wherein like numerals represent like parts throughout the several views, a preferred embodiment of the present invention will be described. Figure 1 shows a typical enclosed automotive lamp or headlight incorporating a humidity control system 200 of the present invention comprising a housing 10, a lens 12, a reflector 14, a bulb 16, and a socket 18 into which bulb 16 fits. Reflector 14 is shown integral with housing 10 in Figure 1, although freestanding reflectors are known and usable with the present invention. Connecting socket 18 and bulb 16 is a bulb/socket locking unit 20. In order to replace bulb 16, socket 18, locking unit 20 and bulb 16 are removed from the back of housing 10. Preferably, locking unit 20 tightly seals socket 18 with housing 10, however it is understandable that there may exist a gap through which air could leak into or out from housing 10. A humidity control system 200 of the present invention is located outside housing 10.

Figure 2 shows an enlarged cross-sectional view of the humidity control system 200 of Figure 1 positioned on lamp housing 10. Likewise, Figures 8 and 9 show enlarged cross-sectional views of humidity control system 210 positioned on lamp housing 10. Humidity control system 200, 210 minimize fog and droplet formation within lamp housing 10 by preventing passage of moisture, either in vapor or droplet form, into housing 10.

System 200 comprises two sections: body or housing 206 and duct 207. Within housing 206 are three sections or areas: a membrane 202, a diffusion channel 203 and a desiccant 101. The membrane 202, diffusion channel 203 and desiccant 101 are positioned within body housing 206 and covered by cap 201. Cap 201 should be seated on body housing 206 so that entrance of water drops, oil drops, or other contaminants into housing 206 is minimized, but flow of air into and out of housing 206 is maintained. Cap 201 may have a slot or hole therein to allow air to flow freely therethrough, or cap 201 may be designed to allow air flow around the edges. Cap 201 minimizes the line of sight or path from the cap exterior to membrane 202 while providing a minimal pressure drop (less than about 0.05 inches of water gauge at a flow rate of 82 ml/min).

System 210 comprises a membrane 202 and diffusion channel 203. System 210 may or may not have a housing 206 encasing membrane 202 and diffusion channel 203. Rather, membrane 202 could be positioned directly over diffusion channel 203 so that diffusion channel 203 provides the support for membrane 202.

Although membrane 202, diffusion channel 203 and desiccant 101 are listed as individual sections or areas, a "section" may be a single layer, for example, membrane 202. Alternately, two or more sections may be integral, for example, desiccant 101 may be located within a section of diffusion channel 203.

Membrane 202, also referred to as a permeable membrane, restricts diffusion of water vapor into housing 10 and system 200, 210 and prevents liquid and other contaminants from entering system 200, 210 and housing 10. Membrane 202 is a microporous membrane or other barrier that allows vapor to permeate therethrough, yet is liquid impermeable. Preferred microporous membrane materials useful in the present invention include PTFE (i.e., polytetrafluoroethylene)

membranes (e.g., GORE-TEX® membranes, available from W.L. Gore and Associates, Inc., Elkton, MD and TETRA-TEX® membranes, available from Tetratec, Inc., Feasterville, PA) and modified acrylic copolymer membranes (e.g., VERSAPORE® membranes, available from Gelman Sciences, Ann Arbor, MI). Permeable, liquid impermeable expanded PTFE membranes are taught, for example, in U.S. Patent Nos. 3,953,566; 3,962,153; 4,096,227, and 4,187,390.

The size and permeability of membrane 202 should be selected such that the pressure drop across membrane 202 is less than about 0.12 inch (30 Pascals) of water gauge at a flow rate of 0.17 ft^3/hr (82 ml/min). In one preferred embodiment, membrane 202 is a hydrophobic membrane with about a 15 mm effective diameter having a resulting area of about 177 mm^2.. Expanded PTFE, commercially available under the trade designation TETRATEX 6279, having a Frazier permeability of 11 FPM (5.6 cm/sec), is a preferred membrane material. Frazier permeability is a velocity value derived from a 0.5 inch of water gauge (124 Pascals) pressure drop. Pressure drop across this TETRATEX membrane material is about 0.07 inches of water gauge (17 Pascals) at a flow rate of 0.17 ft^3/hr (82 ml/min).

Membrane 202 is positioned over and can be attached to diffusion channel 203 with a ring of pressure sensitive adhesive. The diffusion channel 203 is designed to minimize the water vapor diffusion rate while restricting airflow as little as possible. In the static state (i.e., no airflow into or out of the headlight) water vapor will diffuse into the desiccant from the atmosphere, or, if no desiccant is present, into the lamp. A diffusion channel slows this process by providing a long, narrow passage. Diffusion is proportional to the cross sectional area of the channel and inversely proportional to the length of the channel. The adhesive ring which attaches membrane 202 to diffusion channel 203 may have an outer diameter of about 23 mm and an inner diameter of about 15 mm, although other size may be used to correspond to the overall housing 206 and system 200 diameter. The ring of adhesive should only minimally intrude into the area of the membrane through which air flows. The adhesive ring can be laminated to membrane 202 during the step of converting membrane 202 to size.

Enlarged views of diffusion channel 203 is shown in Figures 5, 6A, 6B and 7. Diffusion channel 203 provides a plenum under permeable membrane 202 that allows air to flow toward the center hole through diffusion channel 203. Figure 5, a bottom view of diffusion channel 203, shows the airflow entering channel 203 at the center and then winding through the passage 203' and exiting along the periphery. Diffusion channel 203 typically comprises an extended length of passage compressed into a small space. This tortuous passage can be configured as an inwardly spiraling channel or as a maze-like configuration.

In a preferred embodiment, diffusion channel 203 may comprise a single plastic piece having a tortuous channel carved or molded in the surface thereof. Figure 6A shows a molded diffusion channel 203 with passage 203' open to the atmosphere. The molded surface is then sealed with an impermeable membrane or label 204b, such as mylar, to seal the diffusion channel 203 so that a set number of outlets are present. Impermeable membrane 204b and any adhesive 204a used to adhere membrane 204b to channel 203 preferably have apertures 204a' and 204b' through which the air exits diffusion channel 203. Figure 7 shows the areas through which air can exit. The sealing label 204b, and any adhesive 204a used to adhere the label to the channel, are considered part of the diffusion channel 203. In another embodiment, two plastic pieces may be molded to fit together with a channel therebetween to form diffusion channel 203. An example of a diffusion channel for use with computer disk drive systems is taught in U.S. Patent No. 4,863,499 (Osendorf).

In one preferred embodiment, the outer diameter of diffusion channel 203 is approximately 14 mm. A recessed spiral channel, approximately 20 mm long and 1.5 mm by 1.5 mm in cross-section, leads toward an outer recessed ring. In a preferred embodiment, diffusion channel 203 has a pressure drop of about 0.11 inch of water gauge (27 Pascals) at a flow rate of 0.17 ft^3/hr (82 ml/min). Preferably, the maximum pressure drop is less than about 0.5 inch of water gauge (124 Pascals) at a flow rate of 0.17 ft^3/hr (82 ml/min). Water vapor diffusion through the channel is proportional to the cross-sectional area of the channel divided by its length. In one preferred embodiment, this geometry ratio is about 0.11 mm. Preferably, the maximum geometry ratio is about 0.25 mm. Geometry ratios above this value will

allow moisture to diffuse to the desiccant or interior of the lamp quickly and limit the effectiveness of the moisture removal. In some embodiments, if membrane 202 is sufficiently restrictive to diffusion, it may be feasible to eliminate diffusion channel 203.

At the bottom of diffusion channel 203 is a permeable screen 204 (shown in Figure 3 and exploded in Figure 6B), which separates diffusion channel 203 from desiccant 101. If no desiccant 101 is used, as in system 210, it is not necessary to include screen 204. In some diffusion channel designs it may be preferable to have an impermeable label such as mylar, or other impermeable layer to seal the diffusion channel so that proper diffusion properties are achieved. Screen 204 can be used to prevent debris or other particulate material from moving within system 200. Useable materials for screen 204 include, but are not limited to, nylons, polyesters, polypropylenes, polyethylenes, urethanes, and the like. The screen may be a fabric, a scrim, a grid, a non-woven, a capillary pore membrane, a porous solid, or combinations thereof. Figure 6B shows screen 204 as a laminate of four layers: adhesive 204a, polyester film 204b, another adhesive layer 204a, and scrim 204c. Adhesive layers 204a attach film 204b to screen 204c, and also attach overall screen 204 to diffusion channel 203. The screen may cover the entire surface of a section or may be present on only selected regions, such as shown by the stenciled film 204b and adhesive 204a. The screen may have section which are non-permeable and form a fourth wall of the diffusion channel 203. Any screen should not detrimentally limit the air flow therethrough. Preferably, the pressure drop through screen 204 should be less than 0.05 inch of water gauge (12 Pascals) at a flow rate of 0.17 ft^3/hr (82 ml/min).

Desiccant 101 absorbs and/or adsorbs moisture, both as vapor and droplets, from the air stream. Desiccants and their mode of function are well known. Desiccant 101 may be a single piece of material, however because it is known that a larger surface area produces increased moisture adsorption or absorption rates, desiccant 101 is preferably granular, with particles sizes of between about 60 and 100 mesh. Examples of moisture absorbing desiccant include activated alumina, calcium chloride, silica gel, and zinc chloride. Molecular sieves, absorbent polymers, activated carbon, and clay can also be used.

The desiccant 101 preferably can be regenerated by elevated air temperatures. Heated air, warmed by the operation of the headlight, passes from the interior of lamp housing 10 through the humidity control system 200 and to the exterior atmosphere. As the air passes through desiccant 101 in system 200, moisture collected on desiccant 101 is picked up by the air and is carried out of the system. The resulting desiccant 101 is available for additional absorption and/or adsorption of moisture when needed.

The amount of desiccant 101 in system 200 is typically about 1.0 grams or 3100 mm^3, but more or less can be used, depending on the size of the body housing 206, duct 207, the overall size of system 200, and even the headlight. Particulate desiccant should be packed sufficiently dense so that air passes close to the surfaces of desiccant to maximize adsorption. However, it is preferred to minimize the pressure drop across the bed and an over-packed bed could hinder airflow. Preferably, the maximum pressure drop is about 1.0 inch of water gauge (245 Pascals) at a flow rate of 0.17 ft^3/hr (82 ml/min).

At the bottom of desiccant 101 can be a lower permeable screen (shown as 205 in Figure 3). Screen 205 may be the same or different material than screen 204. The operating characteristics of screen 205, such as permeability and pressure drop, are preferably similar to those of screen 204. Screen 205 can be used to retain particulate desiccant 101 within the adsorptive bed.

The above described sections, membrane 202, diffusion channel 203 and desiccant 101 are preferably housed within housing or body 206. Housing 206 is connected to the interior of lamp housing 10 via duct 207. Housing 206 and duct 207 are connected to, and through, housing 10 by a variety of means, discussed below. In some embodiments, a portion of housing 206 may be formed by lamp 10. For example, a lower or side wall, or combination, of housing 206 may be integral with lamp 10. Preferably, duct 207 terminates within housing 10 in an area of high temperature, thereby increasing the temperature of the air passing through duct 207 and system 200, and thus maximizing desiccant regeneration.

Duct 207 is a hollow elongated tube or straw that connects the sections within housing or body 206 to the interior of lamp housing 10. Lamp housing 10 has a hole 11 therein through which duct 207 attaches, thereby creating

an entry or passage for atmospheric air through duct 207 into the interior of housing 10. Similarly, duct 207 provides a passage for air from the interior of lamp housing 10 out to the exterior of housing 10. Duct 207 may be between about 0.5 to 15 cm long, preferably between about 1 to 10 cm, and most preferably between about 1 to 10 cm, with an inner diameter of about 1 to 10 mm. In a preferred embodiment, duct 207 is approximately 2.5 cm long with an inner diameter of about 4 mm. The volume of air housed within duct 207 is preferably about 320 mm^3.

As shown in Figure 1, body housing 206 is positioned external to lamp housing 10. In a preferred embodiment, duct 207 connects to body 206 and extends through and into lamp housing 10. The system 200 may be positioned so that only a portion (for example, half) of duct 207 is positioned within the interior of lamp housing 10, or system 200 may be positioned so that the entire length of duct 207 extends into the interior of housing 10. The extension of duct 207 into housing 10 allows the end of duct 207 to be closer to bulb 16, thereby increasing the temperature of the air entering duct 207 and passing through system 200. Air heated to higher temperatures improves the regeneration effect of the desiccant within body 206. Preferably, the end of duct 207 is within about 10 cm of bulb 16, preferably within about 7 cm of bulb 16, and most preferably within about 5 cm of bulb 16 in order to have best access to the heated air. The duct may also attach to an internal feature of the headlight which extends the air passage way to an optimal location within the headlight.

In a preferred embodiment, such as shown in Figure s10 and 11, duct 207', which is part of system 200', extends into the interior of the headlight along an internal feature, such as light shield 25 in Figure 10. Light shield 25 is a light diffusion system commonly used for the elimination of bright spots in the area illuminated by the headlight beam. Light shield 25 typically comprises a cup 26 suspended from the top of housing 10 by strut 28. Cup 26 is typically diffusive and is positioned in front of and/or around bulb 16, so that the light, instead of emitting forward from the lamp as a sharp beam from bulb 16, is instead diffused back to reflector 14, which then reflects the light out the front of the lamp. Strut 28 supports cup 26 in front of bulb 16. If viewed from the front of the lamp looking into housing

10, strut 28 would have a minimal cross-sectional area so as to provide minimal interference in light diffusion.

Duct 207' can be placed to extend along the side of strut 28 of light shield 25 or can be directly designed to be integral with strut 28. If designed integral with shield 25, duct 207' may extend along an outer edge or back edge of strut 28. Alternately, duct 207' could be drilled into an existing strut 28 so as to provide a passage through shield 28 to bulb 16. Figure 11 shows system 200' designed to be integral with strut 228 and cap 226. System 200' comprises two sections: body or housing 206 and duct 207'. Within housing 206 are membrane 202, diffusion channel 203 and desiccant 101. The membrane 202, diffusion channel 203 and desiccant 101 are positioned within body housing 206 and covered by cap 201. Duct 207' extends from body housing 206 toward bulb 16 (not shown in Figure 11). Strut 228 and cap 226 can be manufactured together with body housing 206 and duct 207'. Figure 12 shows a cross-sectional view of duct 207' integral with strut 228. As can be seen, the width of strut 28 is minimal so as to provide minimal interference in light diffusion. In some designs, strut 228 could be eliminated so that duct 207' provides the support and placement of cap 226.

By extending duct 207' either with or within a part of light shield 25 into housing 10, it is possible minimize the distance from the end of duct 207' to bulb 16, thereby increasing the inlet temperature and regeneration effect of any desiccant 101 in system 200'. For example, the end of duct 207' could be brought within about 7 cm of bulb 16, preferably within about 5 cm of bulb 16, more preferably within about 2.5 cm of bulb 16, and even with about 1 cm of bulb 16. If duct 207' is run along side or within shield 25, duct 207' is preferably approximately 5 to 8 cm long with an inner diameter of about 4 mm. The volume of air housed within duct 207' is preferably about 650 mm^3.

Body housing 206, cap 201 and duct 207 (and duct 207') are preferably made of moldable plastic material, preferably injection molded. Examples of usable materials include thermoplastics and thermoset materials, which include, but are not limited to, nylons, polypropylenes, polyesters, polyethylenes, polystyrenes, and combinations thereof. The materials may be reinforced with fibers, strands, fillers, or the like. The moldable materials may be thermal curable,

radiation curable (including for example, UV, visible, electron-beam, microwave, radio wave, and infrared), or cationically curable. Photoinitiators, tougheners, curatives and other additives may be added. Body 206, cap 201, and duct 207 (and duct 207'), or any one of these elements, could alternately be made from metal, for example, aluminum. A metal duct 207' is particularly preferred when duct 207' is integral with a metal strut 28 of light shroud 25.

In a preferred embodiment, body housing 206 and duct 207 are integral, that is, formed as one piece. In another embodiment, such as shown in Figure 11, body housing 206, duct 207', and strut 228 and cap 226 of light shield 25 are integral with one another. Optionally, duct 207' could provide the structure of strut 228. Any of body housing 206, duct 207, 207', strut 28, 228 or combinations thereof could be rigid or flexible. A flexible duct 207, 207' may be preferable in tight or cramped areas where flexibility is desirable.

Duct 207 (and duct 207') could optionally be designed to help heat the air passing therethrough. For example, duct 207 could be made from a thermally conductive material, for example, metal or other conductive material, to allow heat to pass through the walls of duct 207 to heat the air retained therein. Duct 207 may be dark in color so as to maximize the absorption of radiant energy generated by the headlight. To increase the surface area and thus heat transfer between duct 207 and the atmosphere, duct 207 could be designed with internal fins, external fins, or a combination of both.

In another embodiment, duct 207 may be formed by a passage through a wall of lamp housing 10. That is, lamp housing 10 may have a thickness sufficient to act as a length of, or even all of, duct 207. The passage could be convoluted to increase the length of the passage. In such instances, no actual duct 207 integral with body housing 206 would be provided, rather, duct 207 is provided by a passage via hole 11 through lamp housing 10.

In some environments, it may be desirable to use system 210, shown in Figures 4A, 4B, 8 and 9, which includes a permeable membrane 202 positioned on diffusion channel 203, to control the humidity in a headlight or other lamp. Figure 4A shows an embodiment of system 210 in an exploded view from a top perspective; Figure 4B shows the system 210 shown in Figure 4A but in an exploded

view from a bottom perspective. System 210 of Figures 4A and 4B would be positioned on a headlight housing so that cap 201 is the outer most portion of system 210. System 210 generally does not include a duct 207 or desiccant 101 as does system 200, but may include a housing 206 and cap 201 designed to encase membrane 202 and diffusion channel 203. System 210 may include any screens of other membranes as desired, although it is diffusion channel 203 and membrane 202 that provides humidity control system 210. Diffusion channel 203 discourages diffusion from outside of the headlight to the interior when there is no, or very low, pressure differential. Membrane 202 eliminates the passage of water droplets and other debris into diffusion channel 203. Membrane 202 is preferably on the exterior of diffusion channel 203.

Membrane 202 of system 210 will generally have the same properties, including area, permeability, etc., as membrane 202 of system 200. Similarly, diffusion channel 203 of system 210 will generally have the same properties as diffusion channel 203 of system 200. Particularly preferred for system 210 is a diffusion channel 203 with a thin, long and tortuous channel. Diffusion, or air flow, through diffusion channel 203 is proportional to the cross sectional area of the channel and inversely proportional to the length of the channel.

As shown in Figure 8, system 210 is positioned within hole 11 in lamp housing 10. System 210 may be seated so that membrane 202, is essentially flush with the outer surface of lamp housing 10; a slight recess may facilitate the seating of system 210 within hole 11. In such an embodiment, system 210 may extend partially into the interior of lamp housing 10.

Alternately, as shown in Figure 9, diffusion channel 203 may be formed integral with lamp housing 10, that is by a long tortuous passage formed through a wall of lamp housing 10. In such instances, no individual diffusion channel 203 would be provided, rather, diffusion channel 203 is provided by a passage through lamp housing 10. The design of diffusion channel 203 within lamp housing 10 will affect whether or not a mylar or other type of impermeable label is needed to seal the channel.

In yet another embodiment, system 210 may extend out away from the surface of the headlight.

Depending on the construction of the system, it may be desired to include one or more support materials between the various sections or in combination with the sections or layers. For example, it may be desirable to include a screen on either or both sides of membrane 202 to provide support for membrane 202. A screen over membrane 202 can also be instrumental in preventing debris or other particulate material from entering system 200. Useable materials for support structures include, but are not limited to, nylons, polyesters, polypropylenes, polyethylenes, urethanes, and the like. The support structures may be a fabric, a screen, a scrim, a grid, a non-woven, a capillary pore membrane, a porous solid, or combinations thereof. Any support structures may cover the entire surface of a section, for example the membrane, or may be present on only selected regions. A support structure such as a screen (in addition to screens 204 and 205) may also be provided on either side of desiccant 101 to contain the particles. Any support structure should not detrimentally limit the air flow through system 200 or cause an excessive pressure drop.

The humidity control system 200, 210 may be attached to, on, in or integral with lamp housing 10 by any suitable method to allow ambient air to flow through system 200, 210 into the interior of lamp housing 10. Air must also be able to flow from the interior of housing 10, through duct 207 and system 200, 210 to the atmosphere. Although Figure 1 shows system 200 positioned on the back side of lamp housing 10, system 200 may be positioned on the top or bottom of the headlight. It is preferable to place system 200 so that duct 207 is fairly close to bulb 16 without creating shadows or other unlit areas. When a granular desiccant 101 is used, it is preferable that flow through the desiccant 101 is vertical. It has been found that when a system such as system 210 is used, system 210 may be positioned at any point on the headlight.

System 200, 210 may be attached to housing 10 by adhesives, thermal bonding, ultrasonic welding, or mechanical means, such as frictional forces, snaps, clips, bolts, screws, and the like. Examples of usable adhesive materials include acrylics, acrylates including methacrylates, silicones, epoxies, urethanes including polyurethanes, butyl rubbers, hot melts, and the like.

An exploded view of the construction of the preferred embodiment of system 200 is shown in Figure 3. Cylindrical body housing 206 is molded plastic, such as polycarbonate or polyester, integral with duct 207. Body 206 has an exterior diameter of about 21 mm with a wall thickness of about 2 mm. Duct 207 is centrally located at the base of housing 206, although duct 207 could be offset from center. Duct 207 has an exterior diameter of about 8 mm with a wall thickness of about 2 mm, and is about 25 mm in length. A protective cap 201 minimizes the line of sight path to membrane 202 while providing low pressure drop.

Hydrophobic membrane 202 made from TETRATEX 6279, having a Frazier permeability of 11 FPM (5.6 cm/sec), a 15 mm effective diameter and a resulting area of about 177 mm^2, is positioned below cap 201.. The pressure drop across the membrane is about 0.07 inch of water gauge at a flow rate of 82 ml/min. Membrane 202 is positioned over molded plastic diffusion channel 203. Diffusion channel 203 comprises a 20 mm long spiral channel having a 2.25 mm^2 cross section. The geometric ratio of channel cross-sectional area to channel length is 0.11 mm. Positioned below diffusion channel 203 and above desiccant 101 is screen 204, a laminate of mylar, permeable scrim and pressure sensitive adhesive. The Frazier permeability of the permeable scrim is about 1000 FPM (508 cm/sec). Portions of the mylar and pressure sensitive adhesive that would cover the outer recessed ring of diffusion channel 203 have been removed to allow air to pass through permeable scrim. The outer diameter of screen 204 is 19 mm. The pressure drop through screen 204 is less than 0.01 inch of water gauge (2.5 Pascals) at a flow rate of 0.17 ft^3/hr (82 ml/min).

Below screen 204 is an absorbent bed of desiccant 101. The bed depth is about 13.5 mm with a bed diameter of about 17 mm, providing a volume of about 3100 mm^3. Preferably, the bed occupies the maximum of inner diameter of housing 206. The mass of silica particulate desiccant 101, having a size of about 60 to 100 mesh, was about 1.0 grams. The pressure drop through the desiccant bed 101 was about 0.75 inch of water gauge (183 Pascal) at a flow rate of 82 ml/min. Below desiccant 101 is screen 205 to retain particulate desiccant 101 thereon.

Screen 205 is a laminate of a non-woven permeable fabric and pressure sensitive adhesive. The Frazier permeability of the laminate is about 1000

FPM (508 cm/sec). The pressure drop through screen 204 is less than 0.01 inch of water gauge (2.5 Pascal) at a flow rate of 82 ml/min. The outer diameter of screen 205 is 16 mm.

It is to be understood, however, that even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only, and changes may be made in detail, especially in matters of shape, size and arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

WHAT IS CLAIMED IS:

1. A humidity control system for preventing condensation in a lamp, the lamp comprising a lamp housing having an exterior and an interior with a bulb therein, the system comprising:

a body having therein a permeable membrane, a diffusion channel, and a desiccant;

a duct extending into the interior of the lamp housing, the duct having a longitudinal length and an interior cross-section area perpendicular to the length, wherein the cross-section area of the duct is less than the cross-sectional area of the body;

the duct connected to the body so as to provide a path for flow of air from the exterior of the lamp housing through the membrane, diffusion channel, desiccant and duct into the interior of the lamp housing.

2. The humidity control system according to claim 1, wherein the body is positioned on the exterior of the lamp housing and the duct extends through a hole in the lamp housing.

3. The humidity control system according to claim 1, wherein the system is attached to the lamp housing by at least one of adhesive bonding and mechanical bonding.

4. The humidity control system according to claim 1, wherein the membrane is a microporous membrane.

5. The humidity control system according to claim 4, wherein the membrane is an expanded polytetrafluoroethylene.

6. The humidity control system according to claim 1, wherein the desiccant is silica gel.

7. The humidity control system according to claim 1, wherein the duct has a length of about 1 to 15 cm.

8. The humidity control system according to claim 1, wherein the duct extends to within 5 cm of the bulb.

9. The humidity control system according to claim 1, the lamp further comprising a light shield and wherein the duct is integral with the light shield.

10. The humidity control system according to claim 1, wherein the duct has an interior cross-section area of about 0.5 to 100 mm^2.

11. The humidity control system according to claim 1, wherein a portion of the duct is integral with a portion of the lamp housing.

12. The humidity control system according to claim 1, wherein the membrane has an area greater than the interior cross-section of the duct.

13. The humidity control system according to claim 1, wherein the desiccant is positioned between the membrane and the duct.

14. The humidity control system according to claim 1, wherein the diffusion channel is positioned between the membrane and the duct.

15. The humidity control system according to claim 1, the housing further comprising a cap.

16. A humidity control system for preventing condensation in a lamp, the lamp comprising a lamp housing having an exterior and an interior, and a bulb positioned within the interior, the system comprising:

a permeable membrane, a diffusion channel, and a desiccant enclosed in a body;

the lamp housing having a passage therein, the passage having a length from the exterior to the interior and forming at least a portion of a duct, the passage having a cross-section area less than the cross-section area of the body,

wherein the duct provides a flow of air between the exterior of the lamp housing and the interior, the air flowing through the membrane, diffusion channel, desiccant and duct.

17. The humidity control system according to claim 16, wherein the length of the passage is the length of the duct.

18. A humidity control system for preventing condensation in a lamp, the lamp comprising a lamp housing having an exterior and an interior, and a bulb positioned within the interior, the system comprising:

a permeable membrane and a desiccant enclosed in a body; and

a duct extending into the interior of the lamp housing, the duct having a longitudinal length and an interior cross-section area perpendicular to the length, wherein the cross-section area of the duct is less than the cross-sectional area of the body;

the duct connected to the body so as to provide a path for flow of air from the exterior of the lamp housing through the membrane, desiccant and duct into the interior of the lamp housing.

19. The humidity control system according to claim 18, the lamp further comprising a light shield and wherein the duct is integral with the light shield.

20. A humidity control system for preventing condensation in a lamp, the lamp comprising a lamp housing defining an exterior and an interior with a bulb therein, and a hole in the lamp housing extending from the exterior to the interior, the system comprising a permeable membrane and a diffusion channel positioned within the hole of the lamp housing, the permeable membrane positioned closure to the exterior than the diffusion channel.

21. The humidity control system according to claim 20, wherein the system extends at least partially into the interior of the lamp housing.

22. The humidity control system according to claim 20, wherein the diffusion channel is integral with the lamp housing.

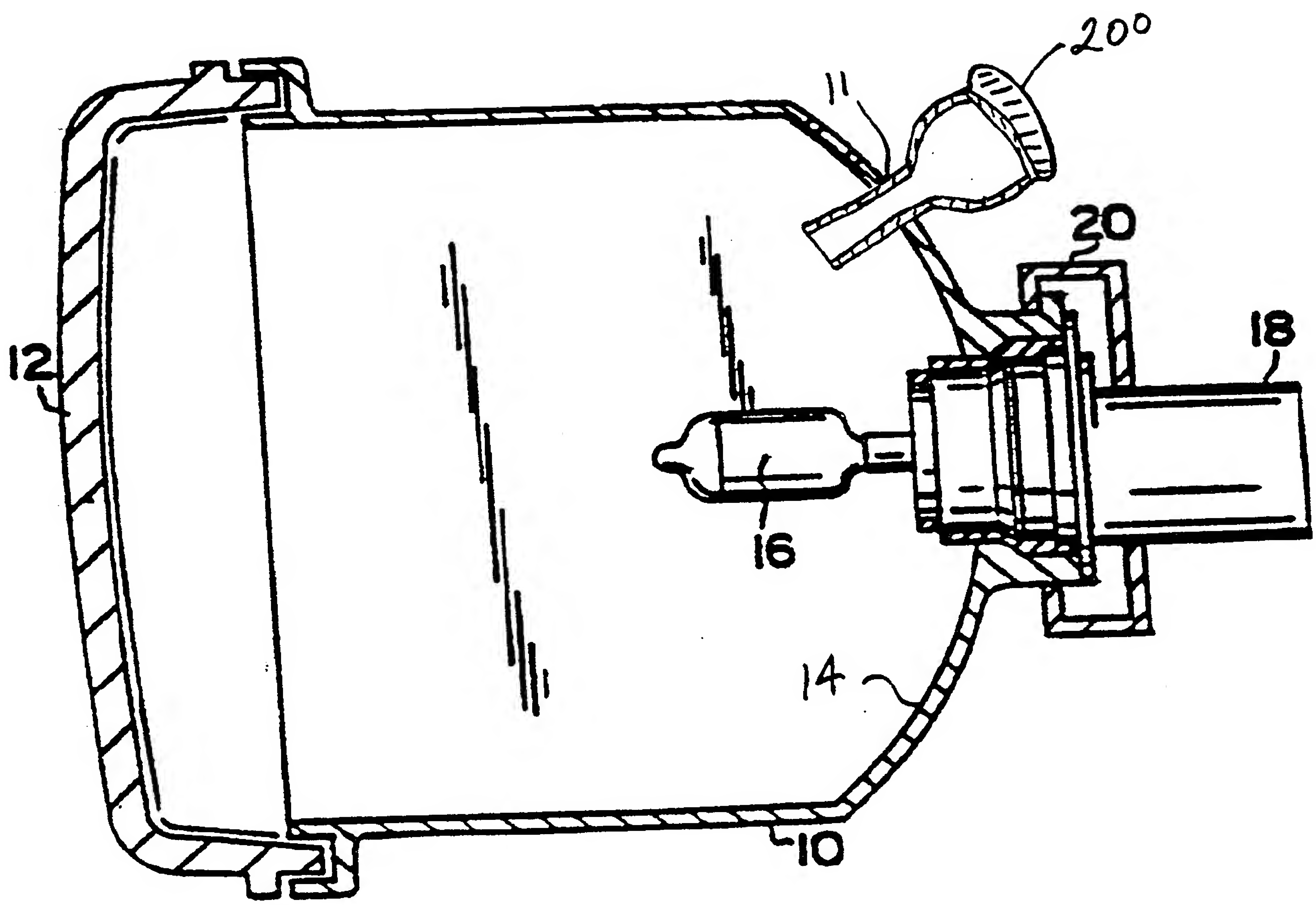

Figure 1.

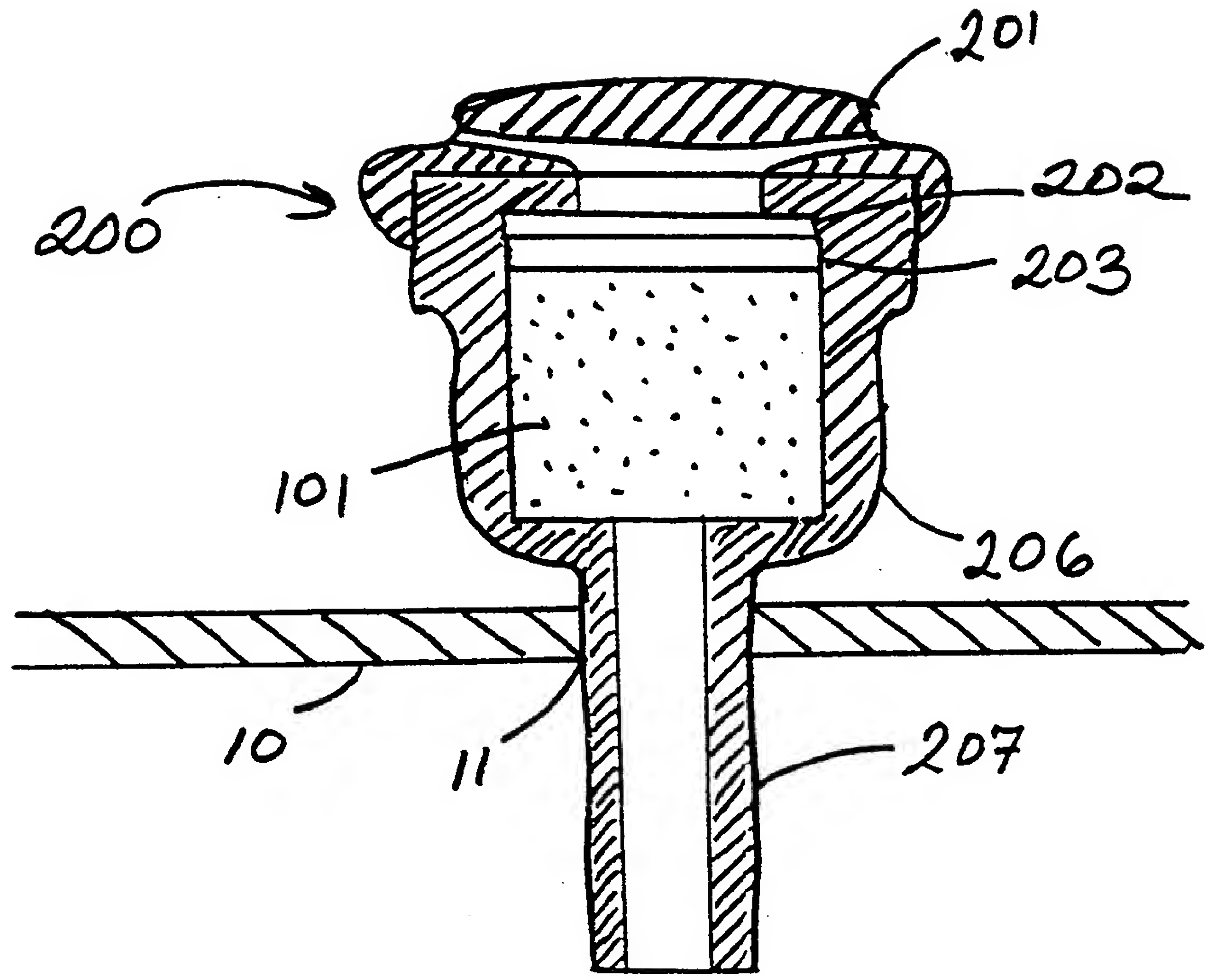

Figure 2.

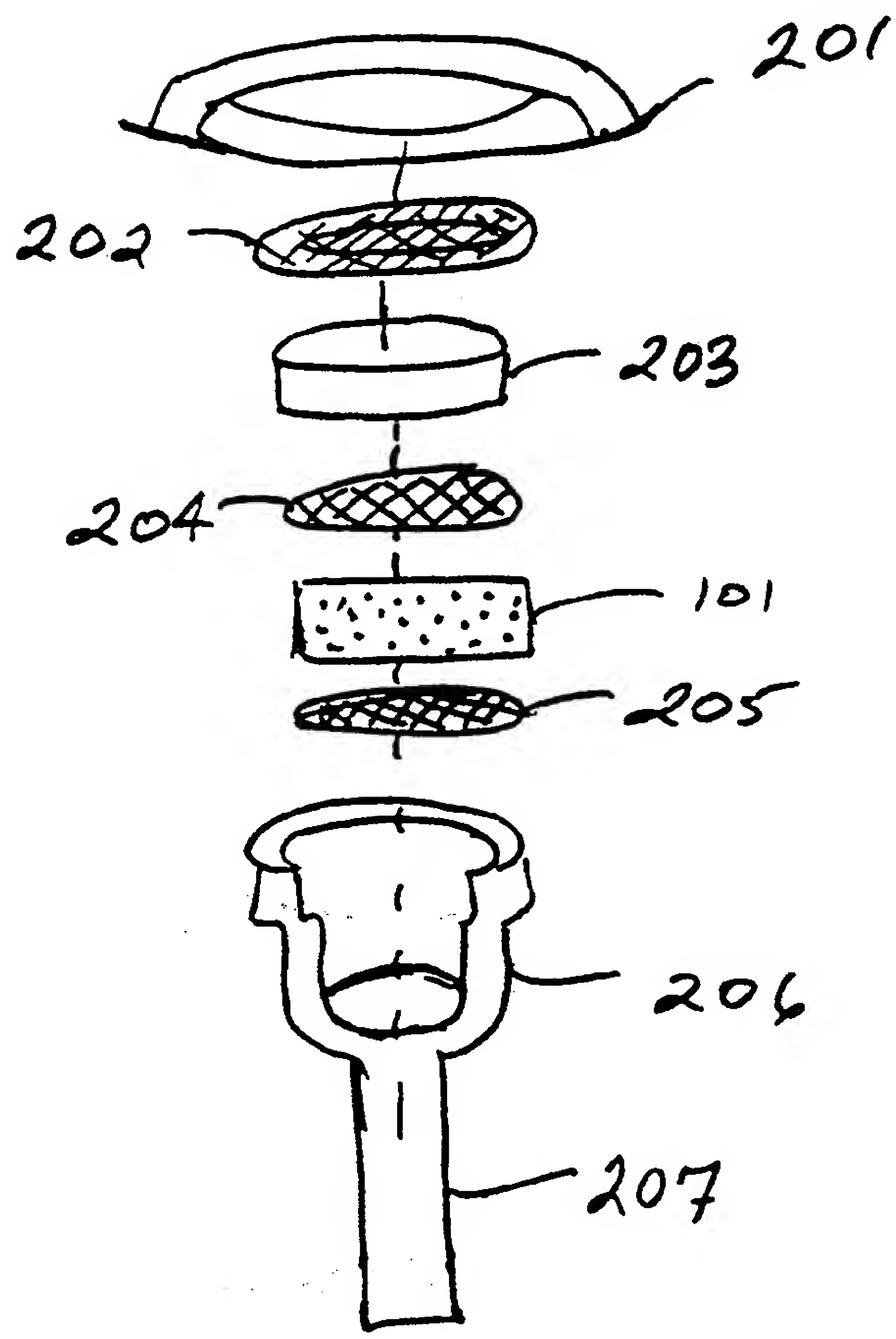

Figure 3.

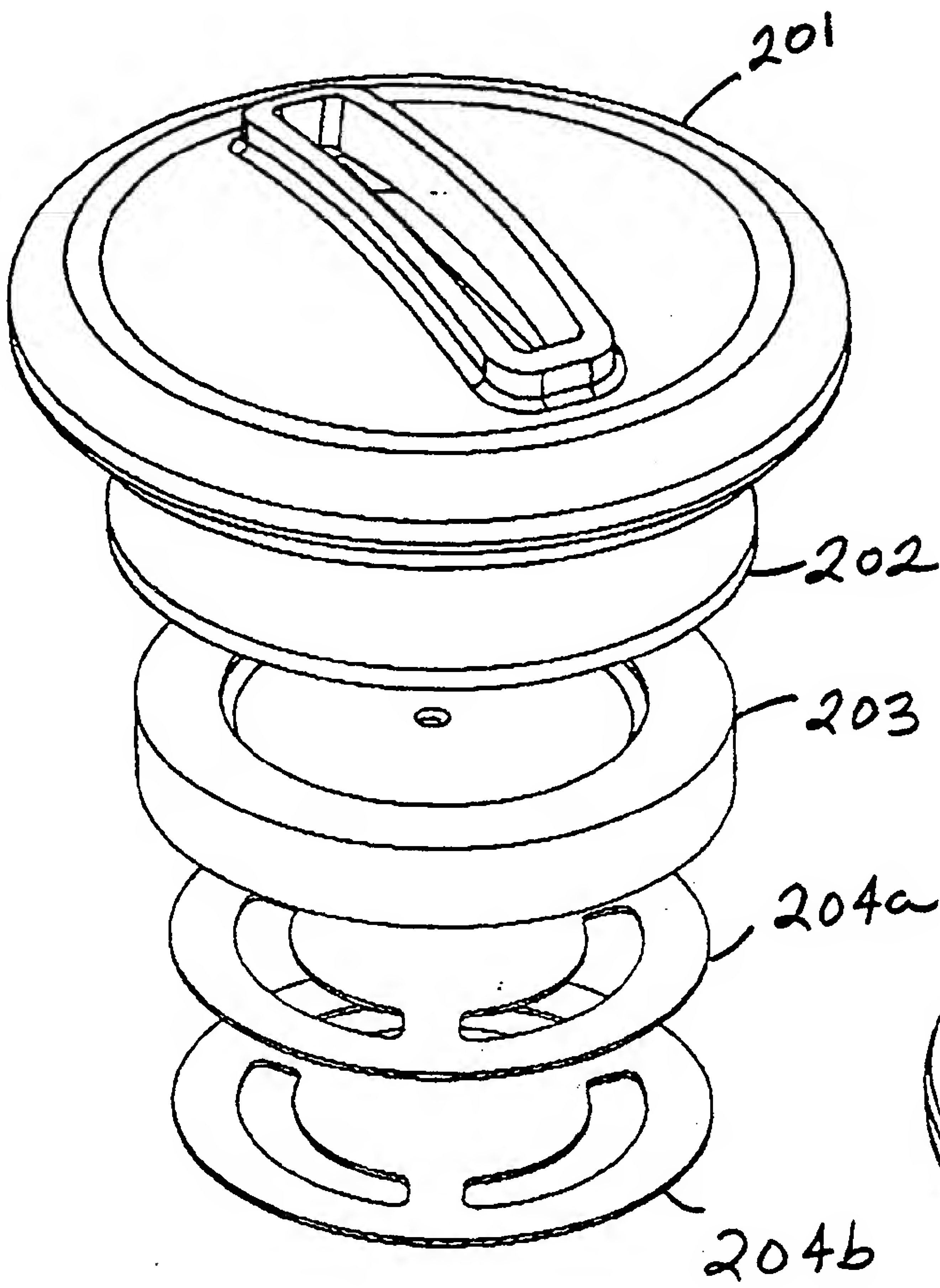

Figure 4A

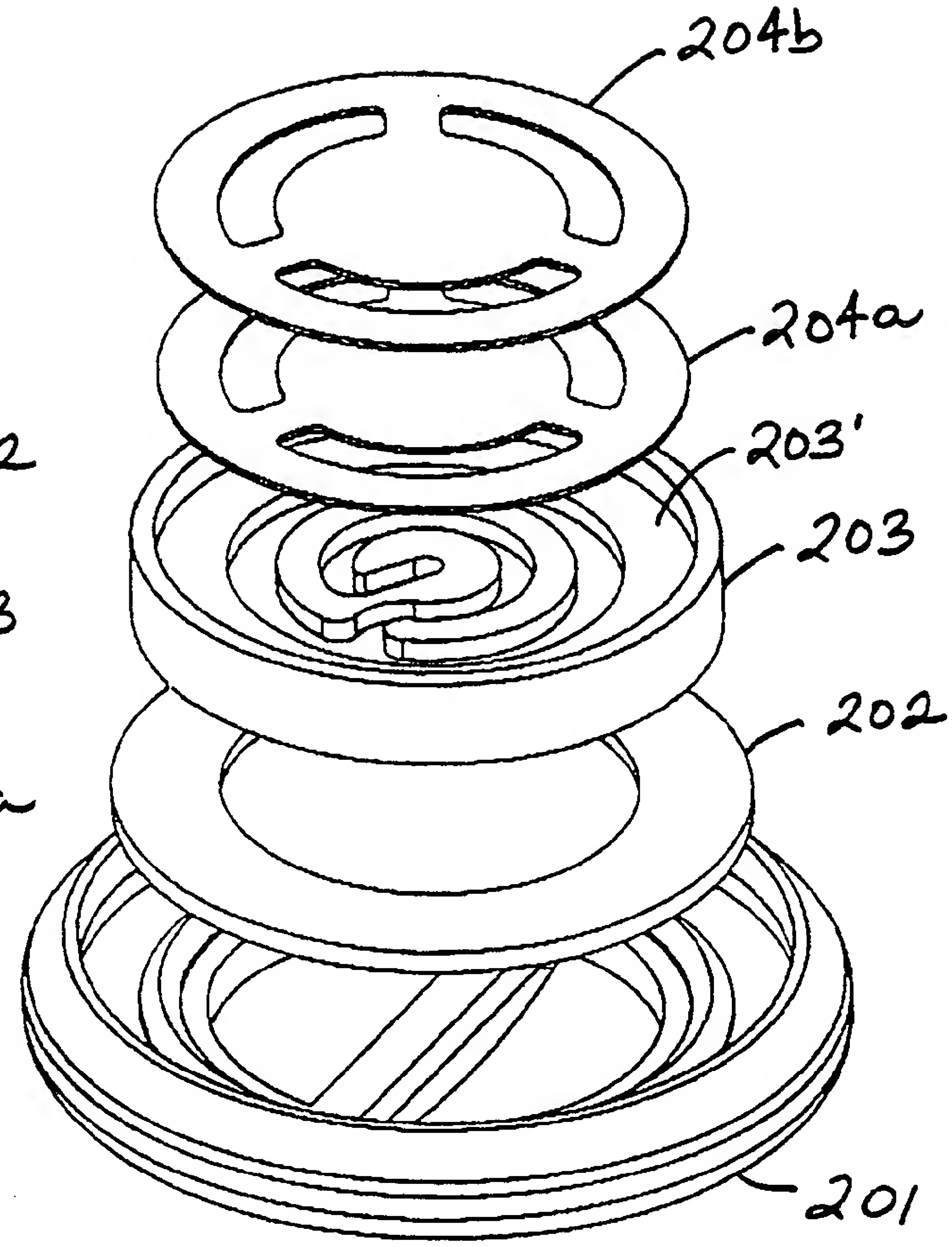

Figure 4B

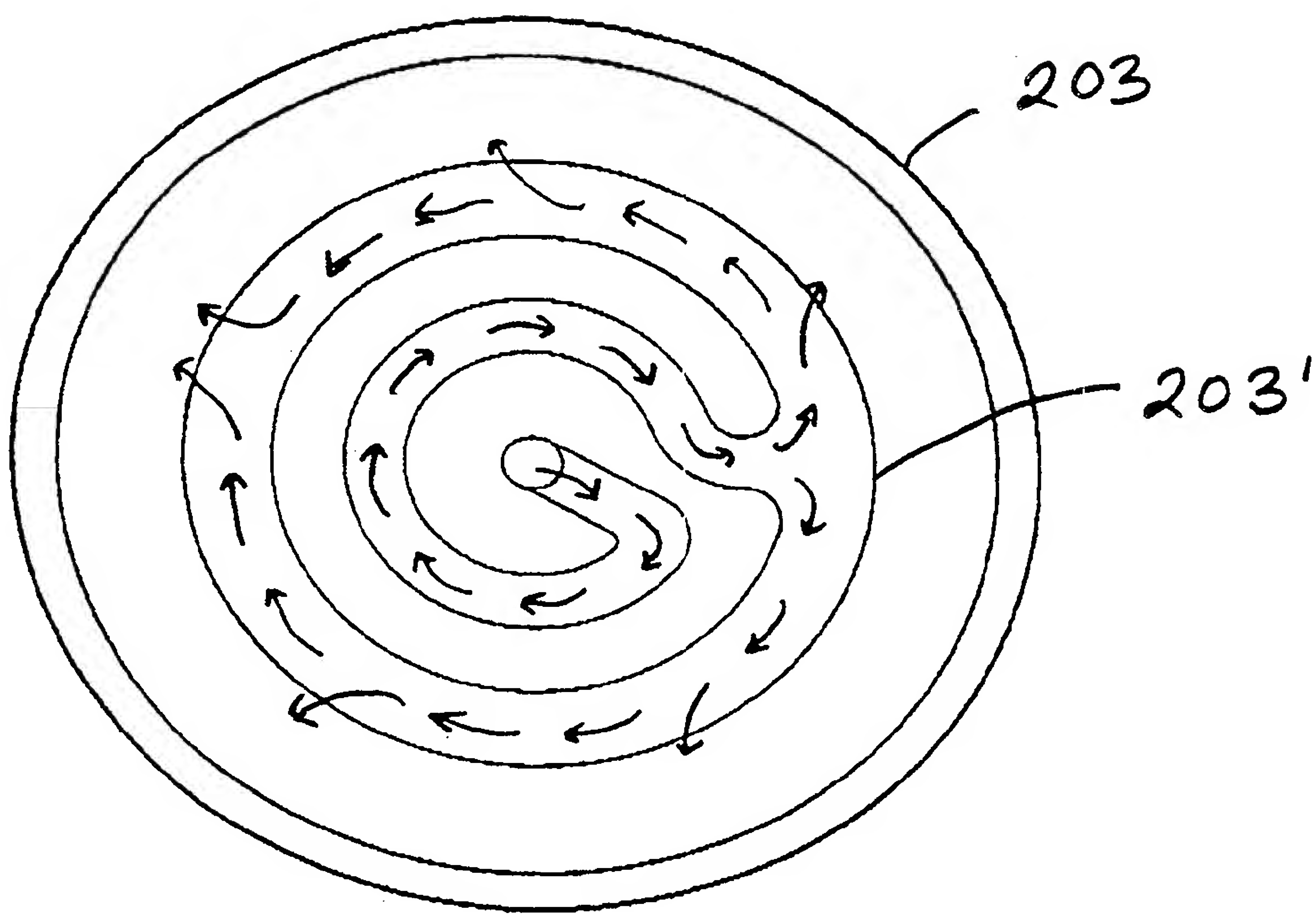

Figure 5

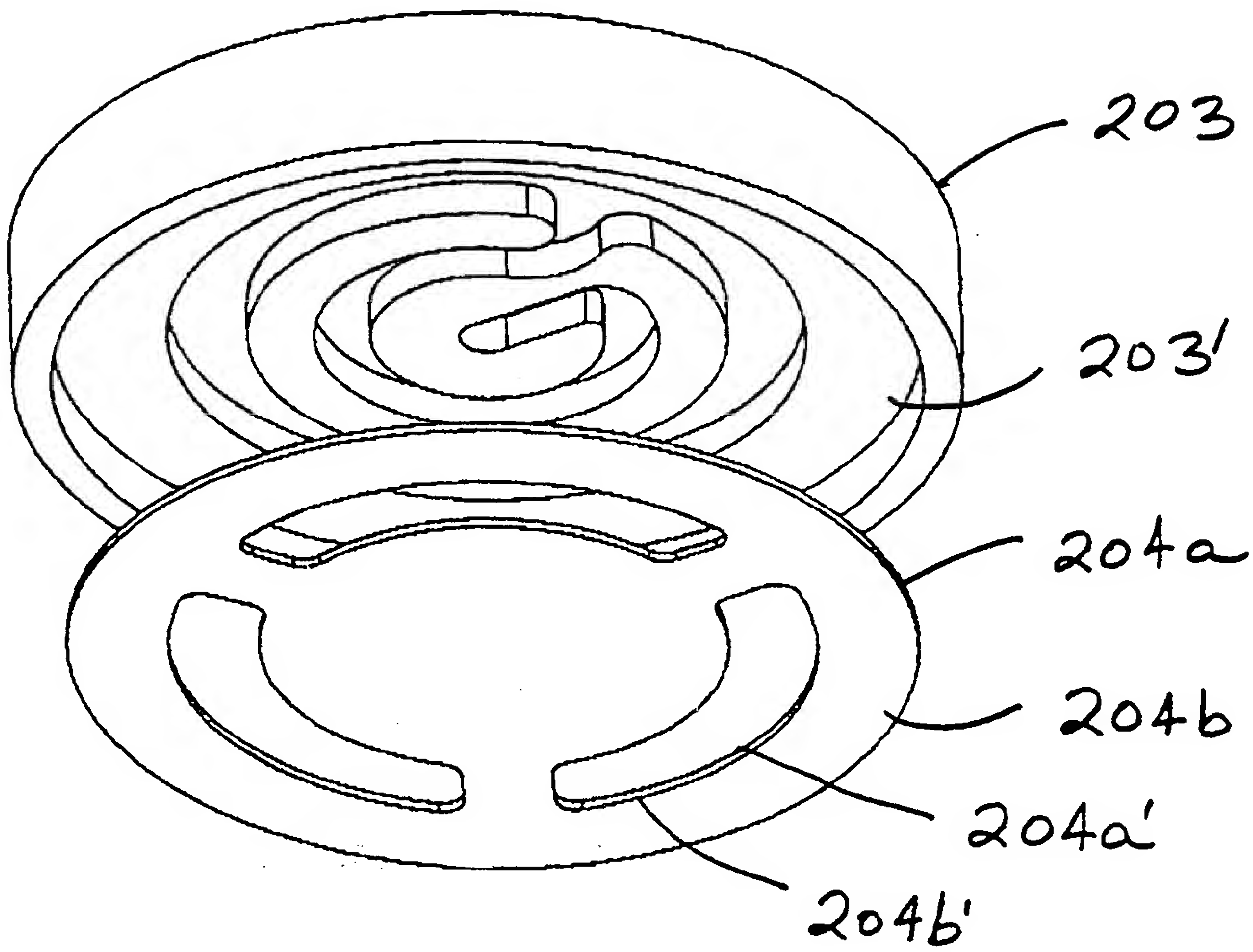

Figure 6A

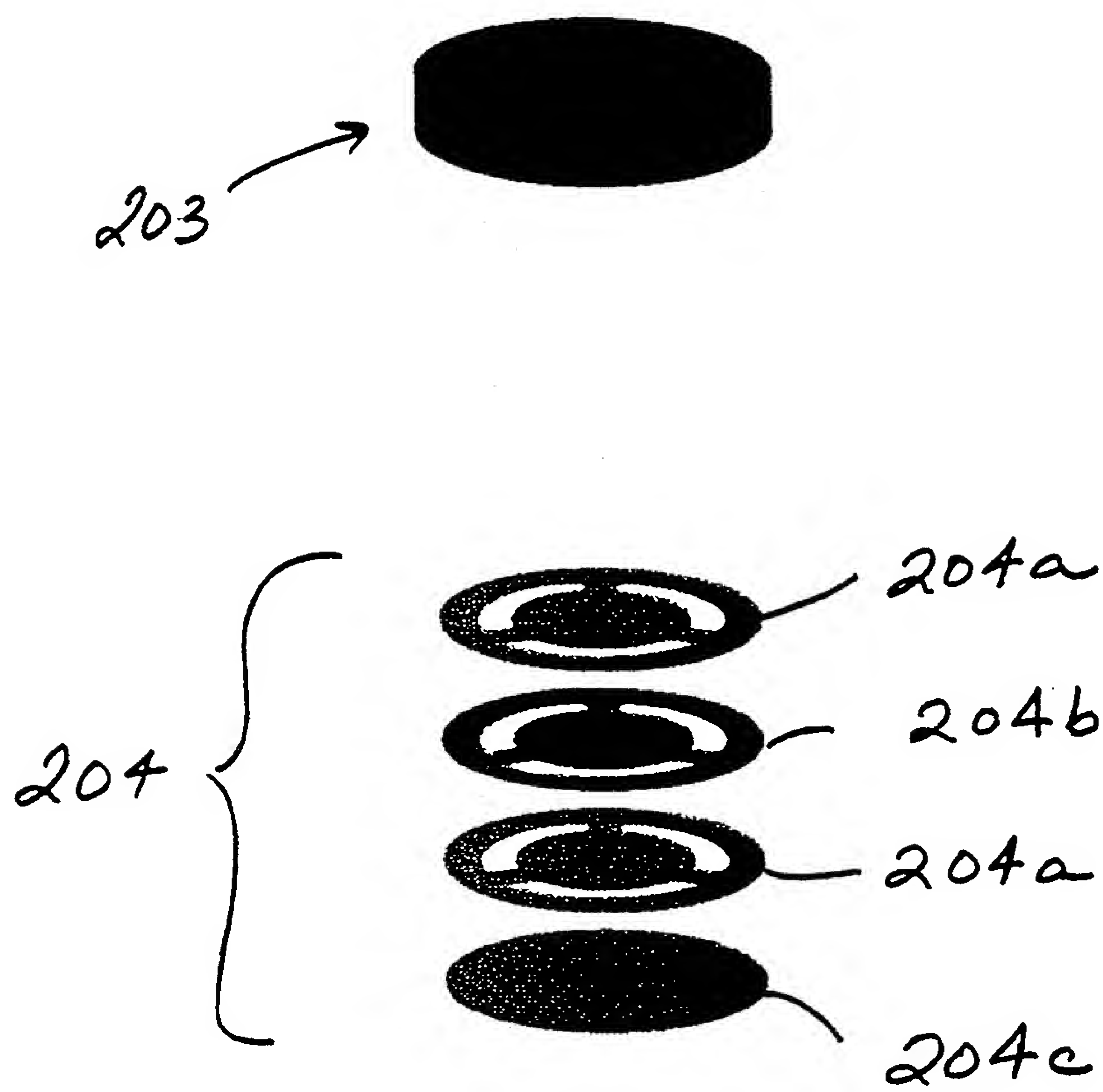

Figure 6B

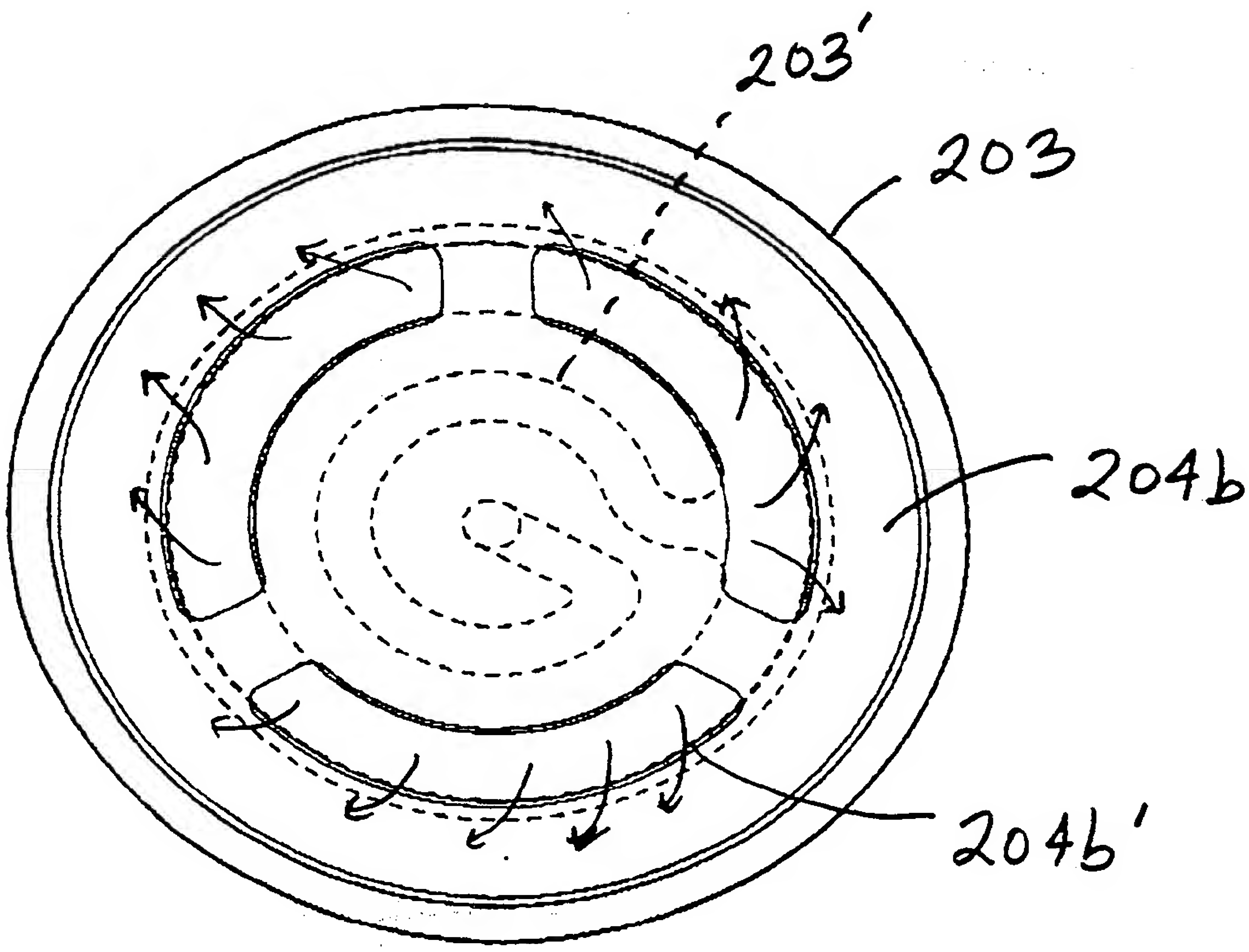

Figure 7

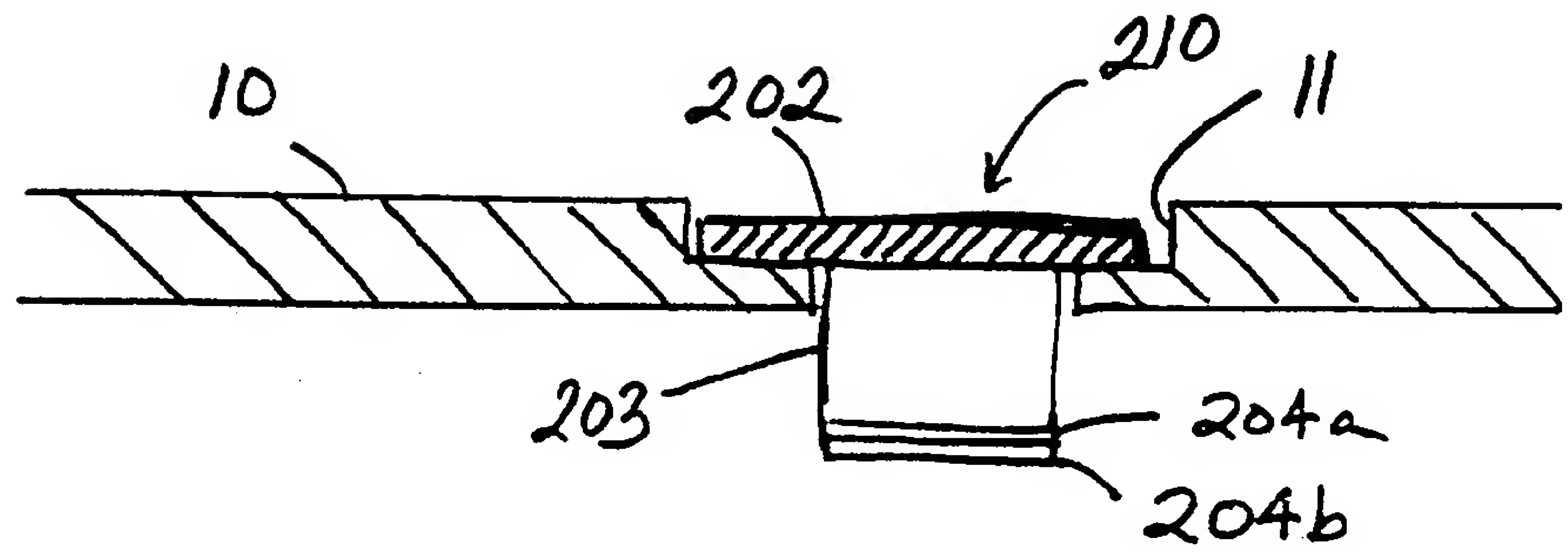

Figure 8

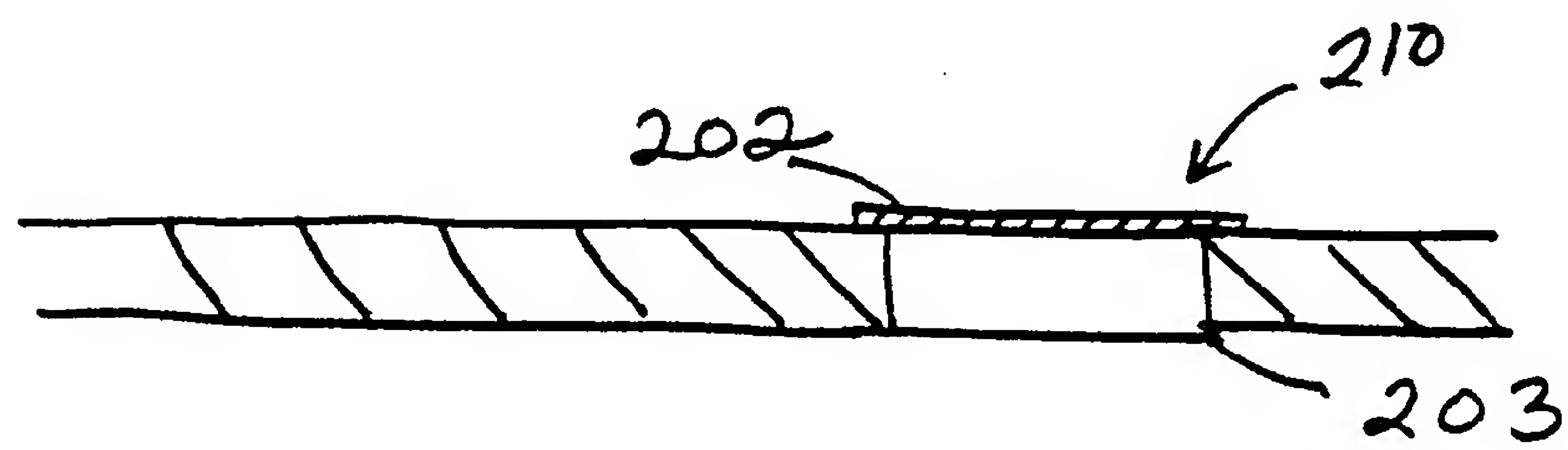

Figure 9

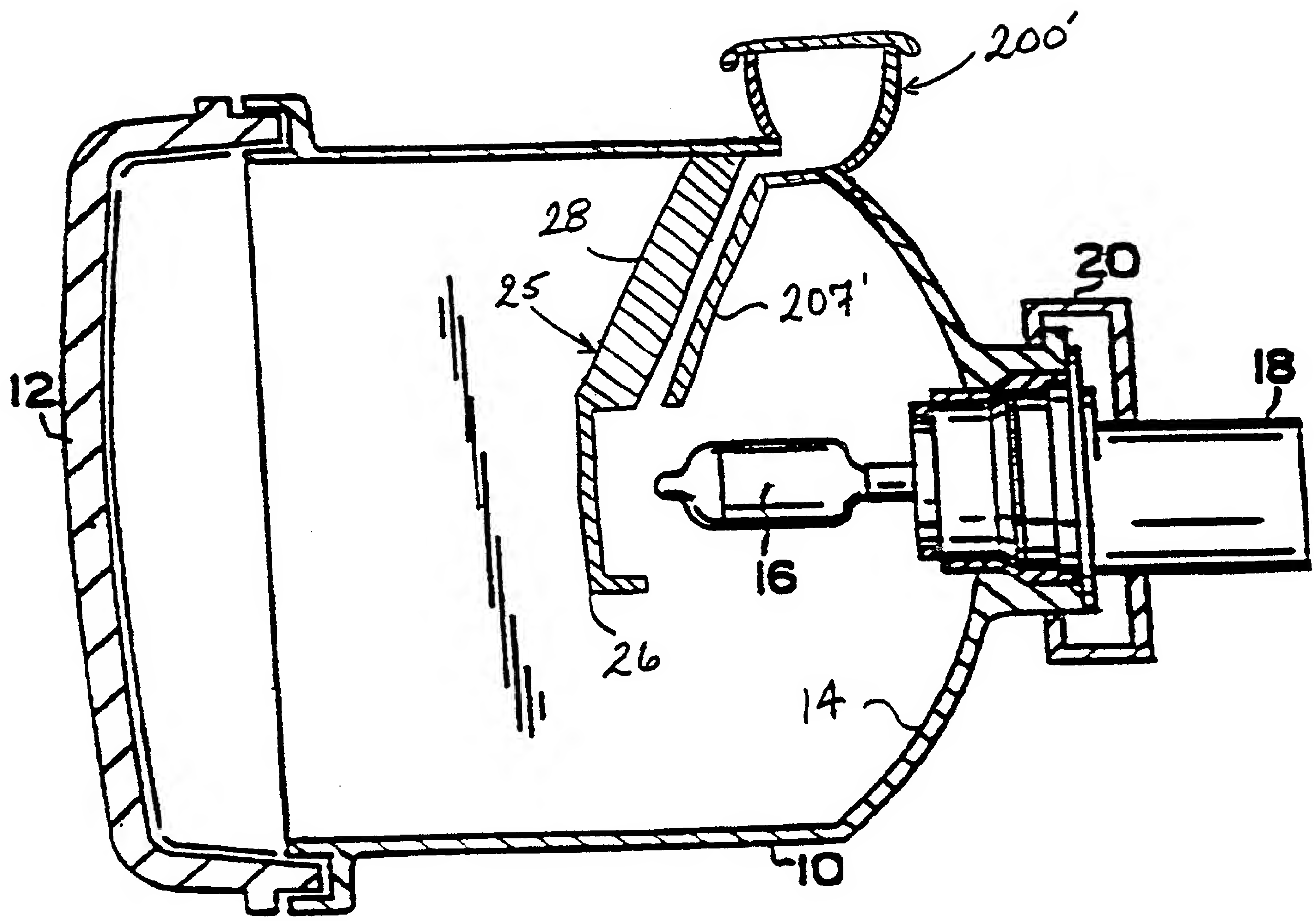

Figure 10

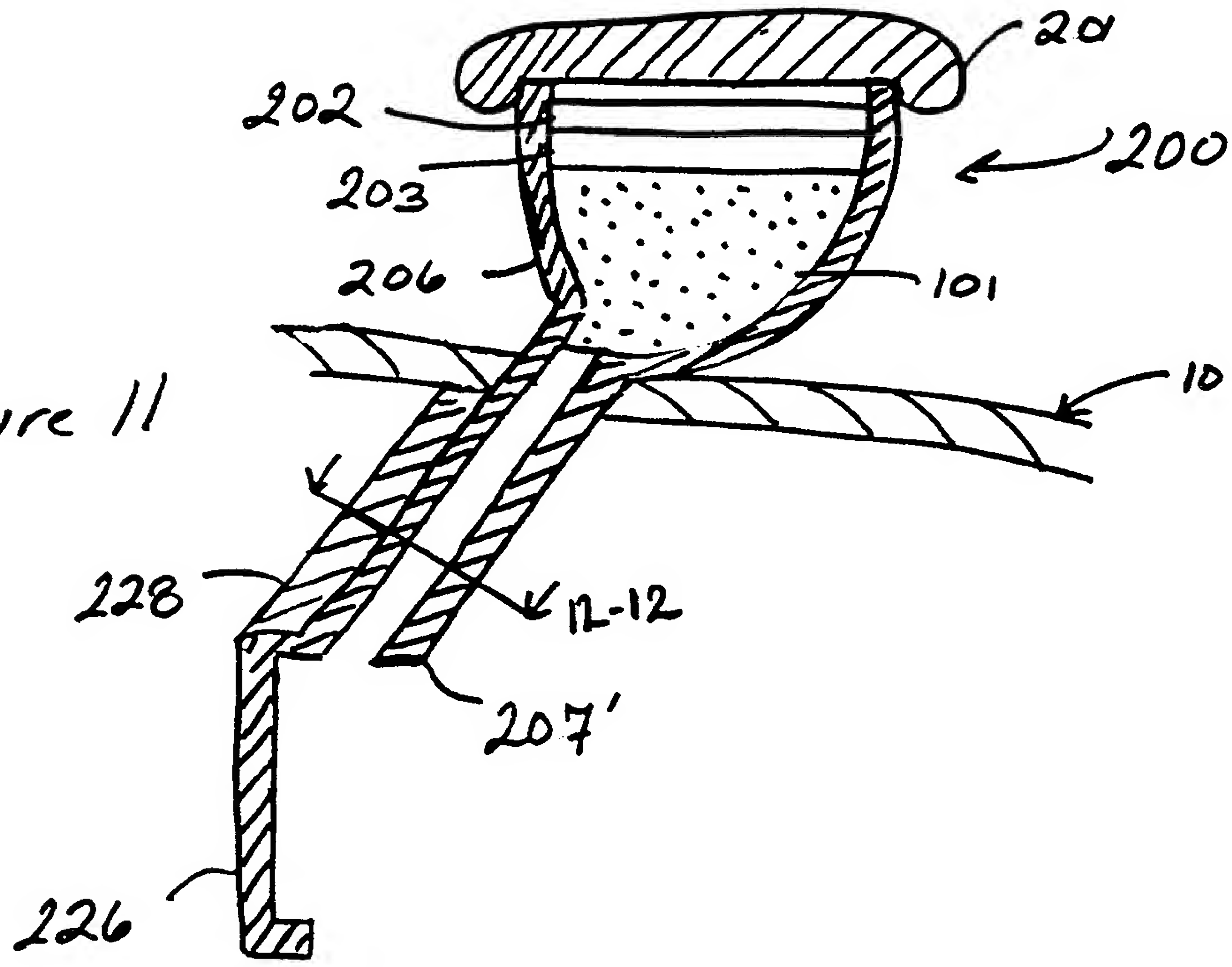

Figure 11

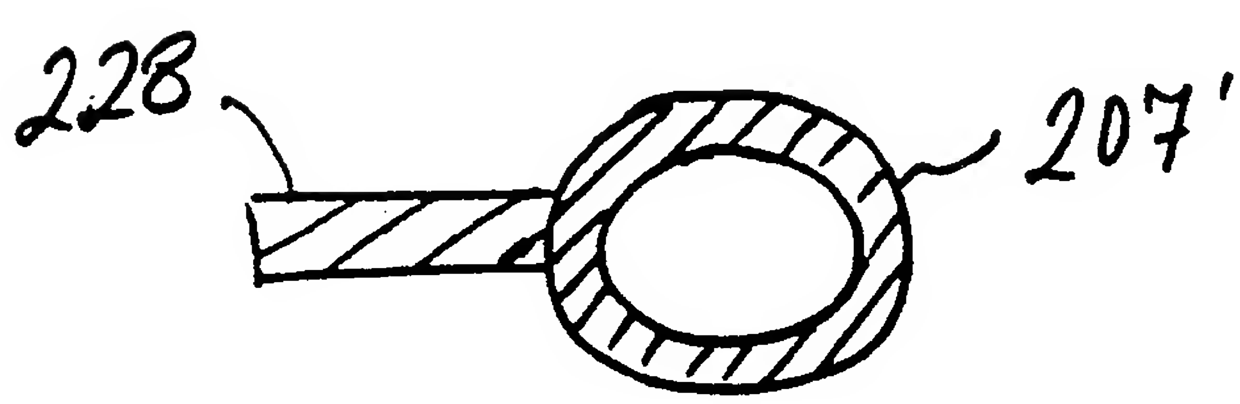

Figure 12

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/01083

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F21V31/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F21M F21Q F21V

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	US 4 809 144 A (SUZUKI TOORU) 28 February 1989 (1989-02-28)	1,11,13, 14, 16-18, 20,22
	column 2, line 32 - line 53 column 3, line 51 - line 63 figures 1,4	
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A		1,16,18

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 May 2000	23/05/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	De Mas, A

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INTERNATIONAL SEARCH REPORT

Int .tional Application No
PCT/US 00/01083

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A		1,3,6, 15,16, 18-22

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Int .tional Application No
PCT/US 00/01083

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